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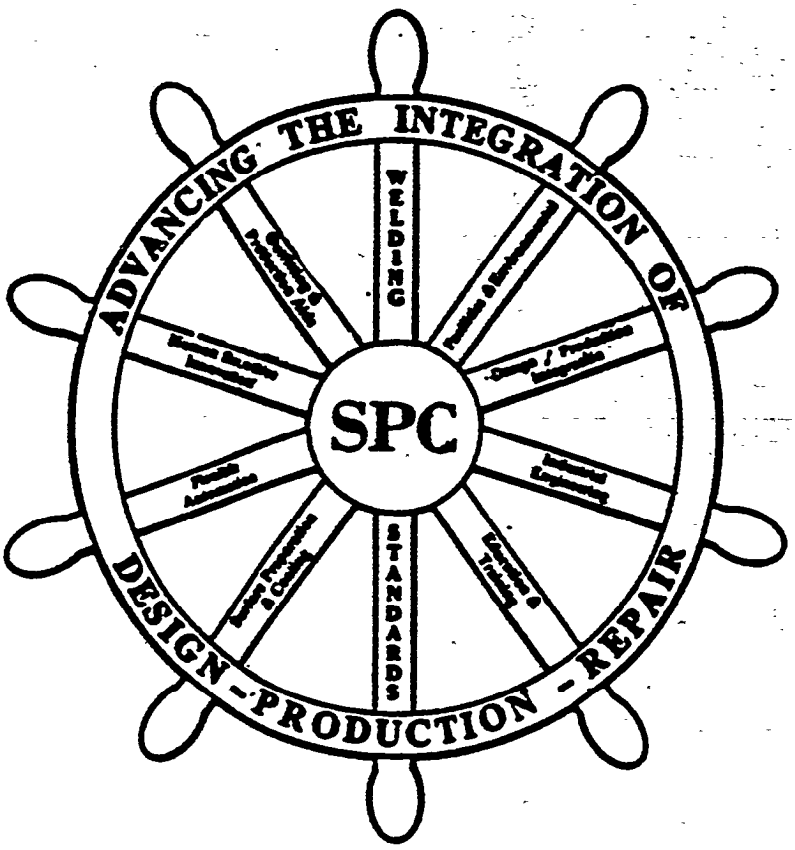

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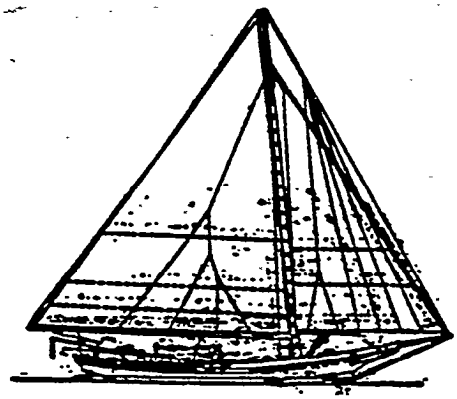

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Revitalization of Industrial Engineering in the Naval Shipyards

No. 5A

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ABSTRACT

Recent developments in the ship repair industry have focused attention on the operation of the naval shipyards. The loss of commercial ship construction work to foreign nations and the declining commercial ship repair work market have resulted in aggressive competition among private shipyards for naval ship repair work. The naval shipyards have come under increasing pressure and scrutiny to become more productive and cost effective. This paper examines the impact of these factors on the naval shipyards, specifically with respect to the industrial engineering functions. The paper describes the initiatives taken to revitalize industrial engineering in the naval shipyards and summarizes some of the successes achieved in reducing costs. The paper concludes with a prognosis for the future and describes efforts to institutionalize the strengthened role of industrial engineering.

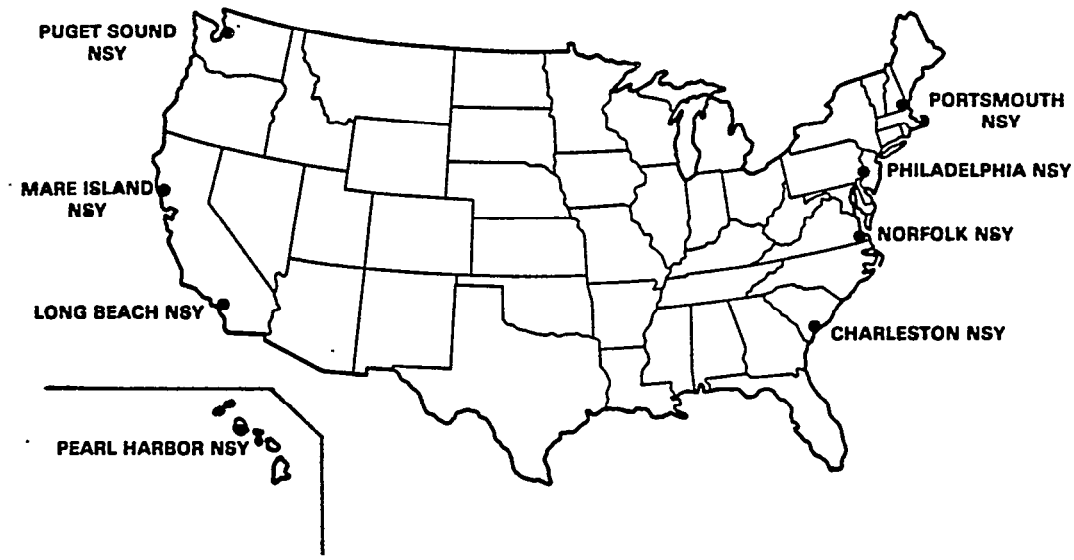
INTRODUCTION

There are 8 naval shipyards, 4 on each coast (considering Pearl Harbor as a West Coast shipyard), located as shown. (Fig. 1) Although they all share a common mission of repair and overhaul of US Navy ships, each shipyard has unique capabilities and specific mission assignments. Portsmouth and Mare Island perform work principally on nuclear submarines; Philadelphia does work on non-nuclear surface ships, including the Service Life Extension Program (SLEP) on non-nuclear aircraft carriers; Norfolk and Puget Sound repair nuclear submarines and surface ships, including nuclear aircraft carriers; Charleston works on nuclear submarines and surface combatants, (excluding aircraft carriers); Long Beach does *work* on non-nuclear surface combatants: and Pearl Harbor repairs all ship classes homeported in Hawaii, Although each shipyard is unique, they all pride themselves in delivering ships back to the navy after repair and modernization in fighting trim, and fully capable of performing their assigned mission. Quality of work has always been the hallmark of the naval shipyards. The naval shipyards are vital to our strategic defense. Maintenance of the skilled labor core and shipyard facilities are critical to our ability to respond in time of national mobilization as well as perform our peace-time mission.

BACKGROUND

The naval shipyards have a long history of serving the fleet: the oldest shipyard, Norfolk, was constructed prior to the Revolutionary War; the newest, Long Beach, was erected during World War II. Total employment levels have varied with a peak in 1943 of about 350,000 at the then 11 naval shipyards; currently

FIGURE 1: **NAVAL SHIPYARDS**



about 70,000 are employed at the 8 shipyards. Up until the late 1960's, the naval shipyards were involved in shipbuilding as well as repair: today their mission is confined to the overhaul, modernization, and repair of naval ships; all ship construction being performed by the private sector.

Organizationally, the naval shipyards are a holdover from the early days of the Industrial Revolution, when the master craftsmen were the dominant force in directing productive efforts and in determining work methods. The shops in a naval shipyard, organized by trade, are to this day managed by former mechanics who, by demonstrating proficiency in their craft, have been promoted to the level of shop superintendent, or shop master as the position is still occasionally referred to. Cultural change comes hard in the naval shipyards: the long standing traditions of organizing work by trade boundaries are not easily changed - one reason why we have been slow to adopt newer work methods, such as zone outfitting. Engineers have traditionally been cast in support roles, called upon to resolve problems, but not expected to play much of a role in establishing productive efficiencies or determining optimum work methods. In fact, since supervisory pay has historically been tied to the size of the work unit, there has been little incentive for shop managers to look for more efficient methods. Frequently, the reward for being productive has been the loss of resources in the form of budget or manpower. Additionally, the staggering number of constraining rules and regulations, particularly in the personnel management area, has fostered a defeatist attitude with respect to change. 'Furthermore, the emphasis in naval shipyards has historically been placed on meeting schedules, frequently at the expense of cost efficiency.

INDUSTRIAL ENGINEERING IN THE NAVAL SHIPYARDS

Industrial engineers are not new

to the naval shipyards. In 1946 the Bureau of Ships issued a directive to all the shipyards defining the responsibilities of the Reads of Departments and Divisions [1]. The Industrial Engineering Officer was described as the Head-of the Management, Planning and Review Division, responsible for conducting studies and preparing reports for shipyard management, "in order to improve and simplify organization, administration, procedures, and utilization of manpower and facilities throughout the Naval Shipyard". A pretty broad charter, but without any teeth in it. Over the years the organization became known as the Management Engineering Office and they still provide reports and support to shipyard managers as well as staff support to the Shipyard Commander in broad areas with little direct control over shipyard operations. The Industrial Engineering identity has gradually disappeared and in recent years, only the Production Engineering Divisions of the shipyards have had much involvement with classical Industrial Engineering functions, and those mostly relegated to the development of engineered labor standards and facilities development.

As early as 1950 a major finding of a study conducted by a Management Engineering consultant firm was that "the navy must assemble a group of trained industrial engineers and appoint in the production shops experienced workmen to develop standards of performance under the technical guidance of industrial engineers" [2]. Although many of the recommendations of that study were disregarded, the Navy did establish a standards program, which has survived to this say albeit with limited success in controlling shipyard costs. The reasons for the failure of the standards program are varied; an underlying cause is the complexity and variability of the ship repair business. In addition, over the years many of the standards have been eroded through adjustment for contingencies, projected growth, personal bias, or specific problems, resulting in standards which have reduced credibility and effectiveness. Even when credible standards have been developed, they may or may not have been accurately reflected in the job estimates, which in turn have been frequently disregarded by those doing the work.

In 1984 another study of the naval shipyards (along with other industrially-funded activities of the Navy) was conducted, this time by Coopers and Lybrand [3]. Once again they found that the shipyards lacked a directed cohesive industrial engineering program. Among their recommendations; "increase the size and involvement of the shipyard industrial engineering organization in all aspects of shipyard operations". The impact of this far-reaching recommendation was diluted by other findings and recommendations which focused on the need to reduce costs, particularly in the overhead area. As a result, although it was generally conceded by shipyard managers that there were inadequate industrial engineering resources in the shipyards, there was a wide spread perception that we couldn't afford to increase the industrial engineering staffs; that if anything, these staffs should be reduced in number along with other overhead functional areas. In fact, during 1985. several shipyards did reduce the number of people in their Production Engineering Divisions, straining the limited industrial engineering resources to an even greater extent.

Fortunately, during the same time frame (1985) NAVSEA headquarters support for and understanding of the important role which industrial engineers could play in improving shipyard efficiency was increasing. Under the leadership of the newly appointed Deputy Commander for Industrial and Facility Management, RADM Roger Horne, additional impetus was given to enhancing the role of industrial engineering in the naval shipyards. Largely due to his personal interest and guidance, the stage was set to revitalize the industrial engineering function with the ultimate objective of bringing down shipyard costs. During this time period, it was becoming increasingly clear that the naval shipyards would have to reduce costs. Shipyards in the private sector were increasingly dependent upon Navy *work,* and as a result, were stepping up their efforts to get a larger share of the Navy workload. A decision was made in the-1984-85 time frame to compete some ship availabilities between the public and-private sectors. A decision-was also made to reduce the 1987 ship maintenance budget for the naval shipyards by $500 million while keeping the workload constant, a 17 percent gain in productivity. At this time also, the federal deficit was getting increased visibility and interest - all factors which clearly showed the need for improved efficiency in the naval shipyards.

THE PLAN OF ACTION

In late 1985 RADM Horne asked that we identify the actions necessary to develop a strong and effective industrial engineering function in the naval shipyards.

In order to answer his request, a group of the shipyard Production Engineering managers was assembled for a two day brain-storming session. The result was a one hour brief to the Admiral, during which the following points were made;

1) The industrial engineering function should remain within the Production Departments of the shipyards since the primary focus of industrial engineering improvement efforts is with the production systems and processes.

2) In order to develop the industrial engineering role, many of the ancillary functions being performed by the Production Engineering groups, such as equipment maintenance support, tool engineering, manufacturing engineering, design of industrial support equipment, rigging engineering, and others, should be reassigned or minimized.

3) Additional industrial engineering resources will be required - both from reassignment of personnel from within the shipyards as well as recruitment of engineering talent from outside the shipyards.

4) Existing resources need to be better utilized, through leveraging of engineers as project team leaders, better training of engineers and technicians, and better screening and prioritization of work.

5) Shipyard management needs to be "sensitized" to the role and potential for industrial engineering in meeting the challenge to reduce costs and become more efficient in doing work.

6) NAVSEA headquarters needs to be more supportive and provide stronger leadership of industrial engineering than it has in the past.

The reaction from RADM Horne was generally favorable to the groups recommendations and we were tasked to "make it happen".

IMPLEMENTATION OF THE PLAN

One of the first things we did was largely symbolic, although very important; that was to change the name of our organization in NAVSEA from the Facilities and Equipment Division, to the Industrial Engineering and Planning Division. Simultaneously, we reorganized by establishing two principal subdivisions or "offices" - one for industrial engineering and the other for capital investments; each headed by a senior level manager. In addition, we transferred people into the industrial engineering branch, gradually increasing the staffing to its current level of four engineers and four technicians.

Early in 1983 a group had been established which gained stature and importance as a result of the renewed emphasis on industrial engineering. The group, Called the NAVSEA Industrial Engineering Steering Group, or "NIESG", was comprised of the shipyard Production Engineering Division Directors and the Director of the then Facilities and Equipment Division of NAVSEA. The purpose of this group was to facilitate the transfer of information among the shipyard Production Engineers and NAVSEA as well as to provide a forum to discuss policy issues of common concern. Initially, despite the name of the group, most of the issues discussed were not related to industrial engineering: they primarily focused on facilities and equipment issues.

When the industrial engineering challenge was recognized in late 1985, the NIESG was a natural vehicle to use in developing a strategy and action plan for the enhancement of industrial engineering. During a December 1985 NIESG meeting at Charleston Naval Shipyard, the NIESG was briefed on the presentation made to RADM Horne and his favorable reaction. At the following meeting, in April 1986, in Monterey California, the group discussed plans and progress being made at the individual shipyards to execute the recommendations approved by RADM Horne. We discovered that many of the Production Engineers were having difficulty in getting shipyard management support for some of the initiatives that they were attempting, such as the reassignment of functions. A RADM Horne policy letter had been signed out in March 1986 to help overcome the obstacle, but little impact had been observed in April [4]. The March letter reiterated the need for naval shipyards to become more cost effective and pointed out that investment in industrial engineering resources should yield favorable returns. Shipyards were strongly encouraged to increase their capability in the industrial engineering area.

1986 was a busy year for everyone involved in the industrial engineering enhancement efforts. At NAVSEA headquarters we began numerous initiatives to foster and encourage expansion of the function in the naval shipyards. One of the problems identified early on was a lack of shipyard management understanding of the industrial engineering function.

Several concurrent actionswere undertaken to address thisconcern. A contract was established with a prominent consultant to teach an introductory industrial engineering course, aimed at Production Department managers who had received little previous exposure to the subject. To date, this course has been presented 10 times, at seven of the eight naval shipyards, and at NAVSEA headquarters. The success of this endeavor has been confirmed by an increasing demand on the part of production shop managers for industrial engineering support.

In August 1986 the NIESG members paid a visit to the headquarters of the Institute of Industrial Engineers (IIE) in Atlanta, Georgia to discuss ways in which the IIE could help to support our efforts. One outcome of the visit was that in October 1986 a Senior Manager from IIE addressed the shipyard production officers during a meeting at Mare Island Naval Shipyard, and described some of the favorable results being achieved in private industry through the application of industrial engineering techniques. Industrial engineering has continued to be an agenda topic for the Production Officers in each of their meetings held since October 1986, resulting in increased awareness of the potential benefits to be achieved through the use of industrial engineers, and support on their part for hiring additional industrial engineers.

In September 1986, the NIESG met in Sturgeon Bay, Wisconsin and visited Peterson Shipbuilders to observe the positive results being achieved by their aggressive industrial engineering efforts including active participation in SP-8. RADM Horne attended the two day meeting and shared with the group his vision of what industrial engineering should encompass in the naval shipyards; ranging from development of an overhaul strategy to the analysis of high cost jobs to effect improvements.

A significant outcome of the September meeting was the establishment of a subcommittee tasked to define the ideal naval shipyard industrial engineering system and to address short and long term implementation strategies. The final report of the subcommittee was issued in August 1987 [5]. Several of the findings and recommendations contained therein were significant and will discussed in more detail later in this paper.

Also during 1986 a program was initiated for the NIESG to visit private industry corporations recognized for their active industrial engineering programs and achievements. Companies visited to date include Dana Corporation, Caterpillar Tractor, 3M Corporation, Rockwell International, and the Quonset Point Division of Electric Boat. These visits have proven especially beneficial in helping to identify industrial engineering techniques which are effective in the private sector and which can be adopted to the public sector. Caterpillar Tractor for example, has recently gone through an adjustment period of dealing with a new competitor, requiring cost reductions. The approach-they used in identifving potential efficiencies has direct applicability to the naval shipyards. In some cases these visits have resulted in a continuing dialog between our shipyard industrial engineering managers with their privat sector counterparts, to their mutual benefit.

During 1986 a formal work sampling program was established at the naval shipyards. In May 1986 NAVSEA tasked the shipyards to begin conducting the studies and provided guidance with respect to the measuring of productive, ancillary, and non-productive activities [6]. The purpose of these studies which are to be conducted at least quarterly, are two-fold. First they can provide statistically reliable data to identify problem areas where corrective action will be cost effective. Secondly, work sampling studies provide shipyard management with information and indicators on productive levels and effectiveness of actions taken. NAVSEA has established a corporate objective of improving shipyard worker productivity by 20% - the work sampling studies results are an indicator of the success achieved in meeting that goal.

Finally in 1986, the Industrial Engineering and Planning Division became actively involved in the National Shipbuilding Research Program (NSRP). The Division Director is designated as RADM Horne's representative to both the Ship Production Committee and the Executive Control Board of the NSRP, and the Division also administers a portion Of the NAVSEA funds provided to support the NSRP.

The hoped-for gains to be achieved through this active involvement in the NSRP include continuation of the development of shipbuilding and ship repair technologies generally fostered by the NSRP, as well as providing a vehicle for the interchange of - information between the private and public shipyard communities in various areas of common interest, including industrial engineering.

INCREASING THE VISIBILITY OF INDUSTRIAL ENGINEERING

During 1987 the tempo picked up. In January 1987 the shipyard commanders were briefed on several industrial engineering topics, including the potential for effecting cost-savings through the application of industrial engineering resources, and the important issue of hazardous waste minimization to be achieved through analysis of industrial processes. Follow on briefings in these and other industrial engineering initiatives have been given at each of the shipyard commanders conferences since. These briefings were successful in building support for the industrial engineering revitalization efforts and facilitated the achievement of two of the recommendations made by the Production Engineering Managers. -Additional staffing was provided during 1987 and some suboptimal functions were reassigned within the shipyards.

Concurrently, an effort was made to sensitize the shipyard commanders of the future. A briefing was presented to the Engineering Duty Officers attending a seven week Basic Course at the Engineering Duty Officer School at Mare Island Naval Shipyard in January 1987, and has been repeated during each session of the course since that time: four times per year. Finally, other shipyard managers, particularly those in the Production departments, have also been briefed on industrial engineering applications in the naval shipyards in order to build a consensus of support for the efforts being undertaken.

In addition to increasing staffing, the Production Engineering Divisions within many of the shipyards reorganized and established Industrial Engineering Branches to give added visibility to the function. Personnel in these Branches were charged to conduct methods and process analyses, and to identify potential areas of cost savings. Several of the shipyards set targets for their engineers of 5 times their salaries in savings to be identified each year. Additionally, industrial engineers were assigned to work directly in the Production Shops, using industrial engineering techniques to analyze problem areas and develop recommendations for improvements to lower costs. The results of these efforts have been impressive and will be described later.

In mid 1987 NAVSEA issued a corporate business plan for the naval shipyards [7]. Specific reference to enhancing the industrial engineering functions was as follows:

> "More emphasis needs to be given to and by the industrial engineering functions to continuously seek ways of improving work processes to optimize resource effectiveness, reduce the volume/toxicity of hazardous waste generation, reduce incidents of rework and generally improve the output of the mechanic...."

Furthermore, application of industrial engineering techniques and resources is an-inherent part of many of the goals and objectives in the plan.

The shipyards responded by developing their own business plans showing the actions to be taken to meet the targets established by NAVSEA including the enhancement of industrial engineering. In order to assure the desired level of attention on industrial engineering functions, NAVSEA subsequently tasked the shipyards to develop a specific strategic plan for increasing their industrial engineering efforts with the ultimate objective of reducing costs and within the context of ten specific target areas [8].

A related issue also addressed by the NAVSEA corporate business plan is in the area of capital investments. Shipyards were tasked to take steps to ensure optimum use of their limited investment funds, based on economic analyses of their projects. Mininum acceptable thresholds of 15% internal rate of return, and 7 year payback were established. NAVSEA issued instructions for the performance of economic analyses to assure consistency and credibility of these calculations 191. Shipyards were notified that they would have to defend their savings projections and show how and where they were effected through budget reductions. Industrial engineering analysis of capital investment projects were thereby emphasized and in fact, required for successful project development.

SUBCOMMITTEE REPORT

The report of the subcommittee established by the NIESG, referred to earlier in this paper, was issued in August 1987. The recommendations of the subcommittee were focused in five areas: organization, training, marketing plan, resources, and applications.

The principal organizational recommendation was that the Production Engineering Division be renamed the Industrial Engineering Division, still located in the Production Department, but with primary mission and objectives oriented around industrial engineering

functions and organized to support those functions. Earlier this year, in January 1988, NAVSEA formalized this recommendation by issuing specific guidance to the shipyards directing the redesignation of Production Engineering as the Industrial Engineering Division.

The second area of subcommittee concern; training, was addressed by short-term (1-6 months), mid-term (6-18 months), and long term recommendations. Short term recommendations included internal shipyard industrial engineering training and shipyard participation at IIE conferences. Although there has been some increase in shipyard activity in these areas, the subcommittee recommendations have not been fully met. Mid term recommendations included conducting IE workshops with customers and utilization of outside training resources such as SP-8 and the Army Management Engineering Training Activity (AMETA). To date these resources have not been used as much as we would like, although some shipyards have AMETA qualified instructors to provide this training locally. The long term recommendations include the development of a IE training curriculum by NAVSEA, and institutionalization of IE training in shipyard apprentice, supervisory, and officer training programs. Our principal focus to date has been on officer training, as discussed earlier. We in NAVSEA are however pursuing the establishment of additional training designed to refresh and enhance specific skills of our engineers and technicians.

The sub committee feld that an aggressive marketing plan would significantly enhance the chances of success of the industrial engineering organization. About half of the shipyards have developed such a plan and have been successful in building customer support through the use of briefings, presentations, and publicity in the shipyard newsletter. The other shipyards are gradually moving in this direction.

Resource recommendations were of two types; the more efficient utilization of existing resources, and the aggressive recruitment of additional resources. Steps have been taken at all eight shipyards in both these areas, but we consider that continuing attention and efforts will be required to assure optimum resource use.

Finally, the subcommittee concluded that implementation of the recommendations in the areas described above would result in the successful application of IE principles in achieving real cost savings. Their recommendation was that each shipyard develop and implement a strategic plan to assure continued improvement and achievement of results. As discussed earlier, NAVSEA subsequently issued specific direction to the shipyards with respect to the development of such a plan.

RESULTS

Up to this point, the content of this paper has been largely descriptive of the initiatives taken to strengthen the industrial engineer's role. This was not however considered to be an end unto itself, the real underlying objective of all this effort was to achieve cost reductions. Although many of the actions taken are long term and will only show results over the long term, there have been improvements which we feel confirm that we are on the right track.

Such things as the consolidation of tank watches from up to 6 people to 1 person; the use of ultrasonic cleaning vice manual cleaning for certain valve components; in place air flask seal testing vice removing the flasks from the ship and transporting them to the inside machine shops; elimination of 55,000 gallons of industrial waste water through the use of an improved ventilation air scrubber design; are all examples of improvements that have been identified as a result of our renewed reliance on industrial engineers. The savings from the four examples cited above are estimated in excess of one million dollars per year and these are a small percentage of the successes we are recording. Industrial engineers are also playing an active role in adopting the use of zone outfitting techniques at some of our shipyards. Projected savings resulting from this innovative approach to ship repair are in excess of $500,000 per ship. Adaptation of techniques and technologies from other industrial applications have yielded additional savings. The use of enzyme/bacteria culture for cleaning of sanitary tasks, previously cleaned by manual labor; expanded use of swaged marine fittings in certain piping systems, are but two more examples of the progress we are making.

Success breeds success, and as positive results are being recorded by our industrial engineers, the enthusiasm and support for increasing the numbers of industrial engineers

has been growing. We feel that it is vital to the success of our efforts to publicize the good things being done by industrial engineers in the shipyards. To this end, earlier this year, in March, we held an Industrial Engineering Symposium in Washington DC, inviting papers from naval shipyard industrial engineering personnel. The two day symposium included 12 papers on topics ranging from successful hazardous waste minimization efforts, to the use of group technology as a means of improving productivity.

Senior headquarters and shipyard managers, including shipyard commanders as well as members of SP-8, were invited to attend, and the large turn out confirmed the level of interest in these industrial engineering topic areas. We plan on holding symposia of this kind on a yearly basis as a means of providing continuing visibility and reinforcement to the efforts of our young engineers and technicians.

THE FUTURE

Where do we go from here? How do we continue to build the momentum achieved from our efforts to date? Most importantly, how can we institutionalize the use of industrial engineering resources and techniques so that it becomes an inherent part of the way of doing business at the naval shipyards, and does not languish from lack of interest as has occurred in the past? As stated previously, successes breed success. It is important to continue to highlight the real productivity improvements that are being identified and achieved through the efforts of the shipyard industrial engineering community. It is also important that we establish a process by which advances achieved at one shipyard can be shared with the other shipyards. To this end, the NIESG established a subcommittee at the January 1988 meeting at Philadelphia Naval Shipyard; tasked to investigate the sharing of information and develop recommendations as to the most effective means of achieving this. The results of this study will be available before the NSRF symposium and will be reported at that time.

We recognize that it takes time to institute change. We are trying to modify a culture and mind-set which has developed over many years in the naval shipyards. Not until an entirely new set of managers who have grown up with the idea of the importance of industrial engineering are in place, can we truly expect full acceptance of the role of industrial engineering in the naval shipyards. Our shipyard military and production shop managers are a product of their environment, which has not fully recognized the advantages to be realized through the use of industrial engineering resources and techniques. In fact, our industrial engineers themselves are not having an easy time breaking out of the sterotype they have been cast in. Many of our engineers still think of themselves as waterfront problem solvers and developers of engineered standards. We must continue to focus on providing training, both for orientation of our managers, and for skills development of our industrial engineers. Finally, we must continue to develop our ties with our counterparts in private industry, through involvement in IIE and SP-8, and visits to private industry leading companies.

There are still many untapped opportunities for our industrial engineering efforts. Areas that we are looking forward to increasing involvement include design for production and industrial planning. Our ship designs have rarely given adequate consideration to maintainability - our industrial engineers have the necessary skills to identify changes which can be made in ship design to improve access and repairability, without compromising the system technical requirements. It is becoming increasingly apparent that investments made in the planning phase of ship availabilities yield high returns in the more efficient execution of work. Our industrial engineers need to assure a more proactive role in the planning function. Finally, industrial engineers must become more involved in the strategic planning of our shipyards. Decisions concerning trade mix, work sequencing, and other overhaul strategy issues have historically been made by managers based on their best intuition and have been frequently driven by workforce considerations. We need to manage our workforce to support our strategy rather than vice versa. Industrial engineering techniques should provide shipyard management with the information they need to make these strategic decisions..

SUMMARY

In conclusion, we are in the midst of exciting and demanding times at our shipyards. Increasing attention on reducing cost and competitiveness is here to stay. We have embarked on a process to increase and enhance our industrial engineering resources as one way to deal with these issues. We

have come a long ways from the days when industrial engineers were primarily used for work measurement and the development of standards. We have a long ways to go before we make full use of this valuable resource. I have a vision of the day when our naval shipyards are recognized as the standards for efficient and effective accomplishments of ship repair and modernization. My vision has the industrial engineers as an inherent part of the shipyard management process, continuously striving for improvement, and continuously achieving results.

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